Earth Observation Potential to Support Africa’s Strategic Water Resources Management Needs

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Outline

• Africa’s Development Context and Water Resources

• The World Bank and Africa’s Water

• Evolving Role of Earth Observation
Africa’s Development Context and Water Resources
Africa faces many development challenges…
Africa faces many development challenges...

Africans livelihoods are still largely agricultural...
Africa faces many development challenges...

Agriculture

Percentage of Water Withdrawal by Sector
- Pie charts size is proportional to actual water withdrawal
- Domestic use
- Industrial use
- Agricultural use
- Equivalent to 7.2 bcm/ly

Actual Water Available (bcm/ly)
- < 30
- 30 - 100
- 100 - 150
- 150 - 300
- > 300
- No data

Sources: Based on data from AQUASTAT (FAO, 2010)
Population pressures are growing…

Data Sources: GPWv3 (CIESIN and CIAT, 2005)
Africa is getting quickly urbanized with large cities growing rapidly...

- Kinshasa
- Cairo
- Lagos
- Khartoum
- Dar-es-Salaam
- Dakar
- Cape Town

Data Source: UN Agglomerations Population Data
Africa faces many development challenges...

Economic Growth

Growing Cities

Growing Economies

Gross Cell Product in 2005
(1995 US$, billions)

Source: The World Bank AFR Water Resources in a Changing Climate, 2010, based on data from GECON GDP Dataset, Yale University 2010
Africa faces many development challenges...

Need to improve access to water supply...

Access to an improved water source in % of total population (in 2005-2009)

- **30 - 40%**
- **40 - 65%**
- **65 - 75%**
- **75 - 85%**
- **85 - 95%**
- **95 - 100%**
- No data

Below world average (85.8%)

Data Source: Improved water source (WHO and UN Children's Fund, JMP, 2009), from the World Development Indicators, World Bank database.
Africa faces many development challenges...

Hydropower
Africa’s Water Resources are primarily in International River Basins...
Africa’s climate shows significant spatial and seasonal variation...
River Flows and Lake Levels are very variable across months and years.

Sources: River discharge UNH-GRDC) and Lake level (USDA/FAS/OGA and NASA Global Agriculture Monitoring (GLAM) Project.)
Africa currently faces many climate risks...

Africa Union: Exposure to Droughts

Drought Exposure

Flood Exposure

Cyclones tracks: 1980 to 2006

Tracks and Intensity of Tropical Storms from 1980 to 2006 included.

Saffir-Simpson Hurricane Intensity Scale
- Tropical Depression
- Category 1
- Category 2
- Category 3
- Category 4
- Category 5

Wind speed (km/h) and Saffir-Simpson Hurricane Wind Scale
- <118 km/h
- 118 - 153 (category 1)
- 154 - 177 (category 2)
- 178 - 209 (category 3)
- 210 - 249 (category 4)
Climate-related disasters take a regular toll on Africa...
Not a year passes...
...without some part of Africa being devastated by floods or droughts...

![Maps showing droughts and floods in Africa in 1971](image)

**Droughts**

- Total number of people affected annually (in thousands)

**Floods**

- Total number of people affected annually (in thousands)

Source: World Bank AFR Spatial Services Helpdesk
Picking Climate Futures...T

Nile Basin - Differences between GCMs, in terms of Change in Annual Temperature by the 2050s

This map shows the temperature change projected by the considered climate model, under the A2 scenario for 2040 - 2069 as compared to 1961 - 1999. Map displays gridded data (cell size=0.5dd).

Disclaimer: The boundaries, colors, denominations, and other information shown in any map do not imply any judgment on the part of the World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

Sources: WCRP’s CMIP3 (Meehl et al. 2007), downscaled by Maurer et al. (2008), rivers (Aquastat, FAO, 2006).
Picking Climate Futures...

Nile Basin - Differences between GCMs, in terms of Change in Annual Precipitation by the 2050s

Monthly Precipitation (mm)
The World Bank and Water in Africa
Water Systems in the Developing World

Triple Bottom-Line Needs

**Economic**
- Low productivity/incomes
- Pricing/Subsidies
- Efficiency
- Sustainable Growth
- Investment Prioritization
- Regional Cooperation

**Environmental**
- Pollution
- Water Productivity
- Groundwater
- Catchment degradation
- Siltation
- Sustainable agriculture
- Floods/Droughts

**Social**
- Poverty Alleviation
- Livelihoods/Equity
- Access to clean water/Health
- Gender/Indigenous People
- Resettlement/Migration
- Low productivity/incomes
- Pricing/Subsidies
- Efficiency
- Sustainable Growth
- Investment Prioritization
- Regional Cooperation
The “Comb” of Integrated Water Resources Management

- Information
- Institutions & Instruments
- Investments

Water Resources Planning & Management

Service Delivery

- Water Supply & Sanitation
- Energy
- Irrigation and Drainage
- Environmental Services (env. flows, pollution mgmt)
- Industry
- Other Uses (incl. navigation)
The 3 Is: Information
Building a Knowledge Base can be difficult...
Existing Hydromet Systems
World Bank Support for Water-Related Information Systems in Africa

• **Knowledge Base Development**
  – GIS, Mapping, Data Sharing/Open Data
  – Partnership with EO providers (e.g. ESA, NASA/NoAA/USGS, etc.)

• **Earth Observation Use Support**
  – Improving capacity of national and regional institutions to use modern earth observation

• **Decision Support Systems Development**
  – Planning, Real-time Management
Knowledge Base and Analysis Development

Average Monthly Precipitation

Eastern Nile Basin: Temperature

Eastern Nile Basin: Precipitation

Eastern Nile Basin: Groundwater

Eastern Nile Basin: Flood Frequency

Source: 0.5° x 0.5° CRU Dataset (University of East Anglia Climate Research Unit, 2000)

Complex Hydrological Structures
- Very high recharge (> 500 mm/year)
- High recharge (100 - 500 mm/year)
- Medium recharge (20 - 100 mm/year)
- Low recharge (< 20 mm/year)
- Very low recharge (< 10 mm/year)

Local and Shallow Aquifers
- Very high recharge (> 500 mm/year)
- High recharge (100 - 500 mm/year)
- Medium recharge (20 - 100 mm/year)
- Low recharge (< 20 mm/year)

Population (persons per sq. km)
- 1 - 5
- 5 - 20
- 20 - 50
- 50 - 100

Flood Frequency (Estimated number of floods per 100 years)
- 1 - 5
- 5 - 20
- 20 - 50
- 50 - 100

Population Density (persons per sq. km)
- 0 - 500
- 500 - 1000
- 1000 - 2000
- 2000 - 3000
- 3000 - 4000
- 4000 - 5000
- 5000 - 6000
- 6000 - 7000
- 7000 - 8000
- 8000 - 9000
- 9000 - 10,000

1990
NBI: Eastern Nile Flood Preparedness and Early Warning Project

Demonstration of Regional Cooperation for flood forecasting and warning improvement in Sudan, Ethiopia, and Egypt.

Flow & WL Hydrographs

- HEC-Geo-RAS
- ARC-GIS

Flood Hazard Maps

- FTA Model
- TRMM Sat.
- CMORPH Sat.
- USGS Sat.
- Observed Met.

Conversion of Rainfall Sat. to Catchment Rainfall (Sudan-FEWS)

Hydrologic & Hydraulic Model (Sudan FEWS)

- HEC-HMS; HEC-RAS; LCM

Upper Nile Rainfall Estimate

Lake Tana Floodplains: Flood Depth Inundation Maps for Gumara during the Period August 8th-12th, 2011

Forecast Date August 8th, 2011
Forecast Date August 9th, 2011
Forecast Date August 10th, 2011
Forecast Date August 12th, 2011
Projected impacts on agriculture crop yields and surface runoff

http://climateknowledgeportal.worldbank.org

Country Vulnerability Profiles

Global Runoff projections

Interfacing Climate & Development

- Historical Climate
- Future Climate Scenarios
- Profiles
- Studies
- Projects
The 3 Is: Institutions
Water Resources Decisions are Complex and Involve Many Actors...

...there is a need for a new generation of tools to tackle old, intractable problems and address new, evolving challenges...
World Bank Support for Water-Related Institutions in Africa

Capacity-building/Training/Access to Expertise/Knowledge and Implementation Partnerships/Facilitating Finance Coordination at various levels:

• **Sectoral**

• **Multi-sectoral**
  – National Basin Agencies, Inter-sectoral Coordination, Committees, etc.

• **Regional**
  – International Basin Institutions (e.g. on Niger, Senegal, Nile, Zambezi, …), Regional Economic Communities

• **Local**
  – Community-level institutions, University Linkages, Innovative approaches (e.g. “Water Hackathons”)
Need for a regional perspective with a key role for Regional Institutions

Sectoral Institutions: e.g. RBOs

Economic Institutions: RECs

Other Institutions: Climate Forecasting Centers, University Partnerships, etc.
The 3 Is: Infrastructure
World Bank Financed Water-Related Infrastructure in Africa

- **Water Supply and Sanitation**
  - Rural, Small towns, Large Urban

- **Agriculture**
  - Rainfed, Irrigation

- **Storage and Hydropower Development**
  - Rehabilitation, New

- **Environment and Natural Resources Management**
  - Watershed Management, Water Quality, Wetlands

- **Information Infrastructure**
  - Hydromet Systems, Planning and Real-time DSS
Targeting Watershed Management Investments (e.g. Malawi Shire Basin)

Hotspots with soil loss > 25 t/ha/y
The Evolving Role of Earth Observation
Earth Observation in WRM

• **Water Systems/Basin Planning**
  – Topographic/Landcover mapping
  – Wetland dynamics
  – Erosion and Sedimentation/Other water quality

• **Investment Preparation and Management**
  – Agriculture (rainfed/irrigation)
  – Hydropower
  – Water Supply
  – Dams
  – Environment/NRM

• **Climate Resilience**
  – Hydromet monitoring
  – Short-term forecasting/disaster mgmt
  – Climate change
Africa’s vegetation is often seasonal...

Irrigation Systems

NDVI from SPOT Vegetation in 10-daily composites

Sudan: By WaterWatch, NL for the World Bank
GDP attributed to the area: 14.2 billion US$
Bangladesh – Current and Future Sea Storm Surge associated with sea-level rise of 1m

Sedimentation & Sea-levels
Real Time Hydromet Measurements

“Bottom-up” From the Ground

Primary Source: Mark Heggli, Innovative Hydrology
Real Time Hydromet Measurements

“Top-down” From Space

“Space-based Groundwater monitoring” e.g. GRACE
Precipitation (rain & snow) → Data Transmission (e.g. Satellite, Fixed-line/Cellphone, Radio Telemetry) → Internet/Intranet

Data Generation
Bottom-up+Top-down

Reservoir Levels

River Stage/Discharge/Sediment

Data Visualization & Use

e.g. Moving to Modern Real-time Hydromet Systems
e.g. Modernizing Flood Management

Data Acquisition & Knowledge Base

Information Access & Stakeholder Interaction

Operational Center

Data Processing

Modeling/DSS

Modernizing Flood Management

Soils
Canals
Wetlands
Rivers

Operational Center
A new world for “last mile” connectivity

-Multiple media
-Internet
-Cellphones
-Flags
-Preparedness plans

CEGIS Flood Info: Lautara 7-Sep-2007 14:21 ++ (Courtesy Banglalink)
Here,
A = Source of flood forecast message
B = Mauza name
C = Date
D = Time of sending message
E = Rise or fall of water level: One plus sign (+) means one bighat (22cm) rise of water level, one minus sign (-) means 1 bighat (22cm) fall of water level.

F=CourtesytoBanglalink

Flag hoisted at the community at Bhalkutia Mauza, Nagarpur Upazila showing rise in water level (blue flag) by 3 bighat

In Summary...

- Improved water resources planning and management is critical for Africa’s Development.
- The World Bank is a key development partner for Africa to strengthen water-related information, institutions, and infrastructure at a scale that can have transformative impact at local, national, and regional levels.
- Evolving Earth Observation tools can provide significant opportunities to accelerate Africa’s sustainable development.
Thank you!

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